Mixed Stoichiometry Practice

Name ____________________

Write and/or balance the following equations (remember the diatomic elements and to criss-cross charges for ionic compounds!!!) Use the mole ratios from the balanced equations to solve the following stoichiometry problems. Use units and labels in all conversions, and round your answer to sig figs.

1. Potassium chlorate decomposes into potassium chloride and oxygen gas.

Balanced Equation: $2KClO_3 \rightarrow 2KCl + 3O_2$

How many moles of oxygen are produced when 3.0 moles of potassium chlorate decompose completely?

$3.0\ mol\ KClO_3 \left(\frac{3\ mol\ O_2}{2\ mol\ KClO_3}\right) = 4.5\ mol\ O_2$

2. Butane (C_4H_{10}) undergoes combustion.

Balanced Equation: 2 $C_4H_{10}(l)$ + 13 $O_2(g) \rightarrow$ 8 $CO_2(g)$ + 10 $H_2O(l)$

How many grams of CO_2 are produced when 88 g of O_2 are reacted with an excess of butane?

$88g\ O_2 \left(\frac{1\ mol}{32g}\right)\left(\frac{8\ mol\ CO_2}{13\ mol\ O_2}\right)\left(\frac{44.02g}{1\ mol\ CO_2}\right) = 6.8g\ CO_2$

3. Water decomposes into hydrogen gas and oxygen gas by electrolysis.

Balanced Equation: $2H_2O \rightarrow 2H_2 + O_2$

a. How many grams of hydrogen will be produced when 6.0 moles of oxygen are produced?

$6.0\ mol\ O_2 \left(\frac{2\ mol\ H_2}{1\ mol\ O_2}\right)\left(\frac{32g}{1\ mol}\right) = 384g\ H_2$

b. How many grams of water are required to produce 1.5L of hydrogen at STP?

$1.5L \left(\frac{1\ mol\ H_2}{22.4L}\right)\left(\frac{2\ mol\ H_2O}{2\ mol\ H_2}\right)\left(\frac{18.02g}{1\ mol\ H_2O}\right) = 1.2g\ H_2O$

mass —— mole —— mole —— mass

4. Cobalt(II) chloride reacts with fluorine in a single replacement reaction to produce cobalt(II) fluoride and chlorine gas.

Balanced Equation: _____ $CoCl_2$ + _____ F_2 → _____ CoF_2 + _____ Cl_2

How many liters of fluorine are required to produce 290.8 g of cobalt(II) fluoride? *Density of Fluorine is 1.7 g/L under the conditions of this experiment.*

$$290.8\,g\ CoF_2 \left(\frac{1\,mol\ CoF_2}{96.93\,g}\right)\left(\frac{1\,mol\ F_2}{1\,mol\ CoF_2}\right)\left(\frac{38.00\,g}{1\,mol\ F_2}\right) = 114\,g\ F_2$$

5. Balance the following equation.

_____ $SrCl_2(aq)$ + _____ $H_2SO_4(aq)$ → __2__ $HCl(aq)$ + _____ $SrSO_4(s)$

What is the mass of strontium chloride that reacts with ~~300.0 g~~ 10mL 3M of sulfuric acid?

$$10\,mL\ H_2SO_4 \left(\frac{1\,L}{1000\,mL}\right)\left(\frac{3\,moles}{1\,L}\right)\left(\frac{1\,mol\ SrCl_2}{1\,mol\ H_2SO_4}\right)\left(\frac{158.52\,g}{1\,mol\ SrCl_2}\right) = 4.7 \rightarrow 5\,g\ SrCl_2$$

6. Solid iron(III) oxide reacts with hydrogen gas to form iron and water.

Balanced Equation:

$$Fe_2O_3(s) + 3H_2(g) \longrightarrow 2Fe(s) + 3H_2O(l)$$

a. How many grams of iron are produced when 450 grams of iron(III) oxide are reacted?

$$450\,g\ Fe_2O_3 \left(\frac{1\,mol\ Fe_2O_3}{159.7\,g}\right)\left(\frac{2\,mol\ Fe}{1\,mol\ Fe_2O_3}\right)\left(\frac{55.85\,g}{1\,mol\ Fe}\right) = 279 \rightarrow 28\,g\ Fe$$

b. How many grams of water will be produced when 3.2L of hydrogen gas react completely with iron(III) oxide at STP?

$$3.2\,L\ H_2 \left(\frac{1\,mol\ H_2}{22.4\,L}\right)\left(\frac{3\,mol\ H_2O}{3\,mol\ H_2}\right)\left(\frac{18.02\,g}{1\,mol\ H_2O}\right) = 2.6\,g\ H_2O$$

3 Ways to solve these problems

LIMITING REAGENT Practice Problems

1. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:

$$Fe\ (s) + S\ (l) \rightarrow FeS\ (s)$$

#1 Compare mole ratios

In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.

a. What is the limiting reagent, and what is the reactant in excess?

7.62 g Fe (1 mol Fe / 55.85 g) = 0.136 mol Fe   8.67 g S (1 mol S / 32.06 g) = 0.268 mol S

need 1 mol Fe / 1 mol S   have 0.136 mol Fe / 0.268 mol S

Fe is limiting

b. Calculate the mass of FeS formed.

7.62 g Fe (1 mol Fe / 55.85)(1 mol FeS / 1 mol Fe)(87.92 / 1 mol FeS) = 12.0 g FeS

2. Arcylonitrile, C_3H_3N, is the starting material for the production of a kind of synthetic fiber acrylics) and can be made from propylene, C_3H_6, by reaction with nitric oxide, NO, as follows:

$$4\ C_3H_6\ (g) + 6\ NO\ (g) \rightarrow 4\ C_3H_3N\ (s) + 6\ H_2O\ (l) + N_2\ (g)$$

What mass of C_3H_3N can be made when 21.6 g of C_3H_6 react with 21.6 g of nitric oxide?

#2. determine exact amount of reactants needed

21.6 g C_3H_6 (1 mol C_3H_6 / 42.06 g)(6 mol NO / 4 mol C_3H_6)(28.01 g / 1 mol NO) = 20.6 g NO

20.6 g NO needed but you are given 21.6 g

NO is in excess

C_3H_6 is limiting

3. Formic acid, $HCHO_2$, burns in oxygen to form carbon dioxide and water as follows:

$$HCHO_2\ (aq) + O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l).$$

A B C

If a 3.15-g sample of formic acid was burned in 2.0 L of oxygen, what volume of carbon dioxide would be produced? (Assume the reaction occurs at standard temperature and pressure, STP.)

#3 determine product for each reactant.

3.15 g $HCHO_2$ (1 mol / 46.03 g)(2 mol CO_2 / 1 mol $HCHO_2$)(22.4 L / 1 mol CO_2) = 3 L CO_2

limiting

2.0 L O_2 (1 mol / 22.4 L)(2 mol CO_2 / 1 mol O_2)(22.4 L / 1 mol CO_2) = 4 L CO_2

least amount of product formed

4. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

   a. Balance the following reaction: ___ Zn (s) + 2 HCl (aq) → ___ $ZnCl_2$ (aq) + ___ H_2 (g)

   b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid.

   3.50g Zn (1mol Zn)

   Complete the following table:

Reactants/products	Zn (grams)	HCl (grams)	$ZnCl_2$ (grams)	H_2 (L)
Before reaction	3.50g	2.50g	0	0
After reaction	1.26 g	0	4.67	0.768

Zn is excess reactant

5. Consider the reaction: $MnO_2 + 4\ HCl \rightarrow MnCl_2 + Cl_2 + 2\ H_2O$

   If 0.45 mols of MnO2 can react with 48.2 g of HCl, how many grams of Cl_2 could be produced?

   $0.45\ mol\ MnO_2 \left(\frac{4 mol\ HCl}{1 mol\ MnO_2}\right)\left(\frac{36.46}{1 mol\ HCl}\right) = 65.628g\ HCl$ (limiting)

   $48.2g\ HCl \left(\frac{1 mol\ HCl}{36.46g}\right)\left(\frac{1 mol\ Cl_2}{4 mol\ HCl}\right)\left(\frac{70.9g}{1 mol\ Cl_2}\right) = 23.4g\ Cl_2$

6. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine, N_2H_4, and dinitrogen tetraoxide, N_2O_4. If the balanced equation for this reaction is

   $$2\ N_2H_4\ (l) + N_2O_4\ (g) \rightarrow 3\ N_2\ (g) + 4\ H_2O\ (g),$$

   A B C

   What volume of N_2 gas (measured at STP) would result from the reaction of 1500 kg of hydrazine and 1000 kg of N_2O_4?

   $1.5\times10^6 g\ N_2H_4 \left(\frac{1 mol\ A}{32.04g}\right)\left(\frac{3 mol\ N_2}{2 mol\ A}\right)\left(\frac{22.4L}{1 mol}\right) = 1.6\times10^6 L$

   $1\times10^6 g\ N_2O_4 \left(\frac{1 mol\ B}{92.09}\right)\left(\frac{3 mol\ C}{1 mol\ B}\right)\left(\frac{22.4L}{1 mol}\right) = 7\times10^5 L\ N_2$

   N_2O_4 limiting

7. Chlorine gas reacts with silica, SiO_2, and carbon to give silicon tetrachloride and carbon monoxide.

   a. Balance the following equation: 2 Cl_2 (g) + __ SiO_2 (s) + 2 C (s) → __ $SiCl_4$ (l) + 2 CO (g)

   b. How much CO gas can be produced from 15.0 g of silica? AT STP

   $15.0g\ SiO_2 \left(\frac{1 mol\ SiO_2}{60.09}\right)\left(\frac{2 mol\ CO}{1 mol\ SiO_2}\right)\left(\frac{22.4L}{1 mol\ CO}\right) = 11.0\ L\ CO$

Theoretical and Percent Yield Worksheet

1. Given the following equation:

$\underline{1}$ K_2PtCl_4 + $\underline{2}$ NH_3 --------> $\underline{1}$ $Pt(NH_3)_2Cl_2$ + $\underline{2}$ KCl

   a) Balance the equation.
   b) Determine the theoretical yield of KCl if you start with 34.5 grams of NH_3.

$34.5\ g\ NH_3 \left(\frac{1\ mol\ NH_3}{17.06\ g}\right)\left(\frac{2\ mol\ KCl}{2\ mol\ NH_3}\right)\left(\frac{74.55}{1\ mol\ KCl}\right) = 151\ g\ KCl$

   c) Starting with 34.5 g of NH_3, and you isolate 76.4 g of $Pt(NH_3)_2Cl_2$, what is the percent yield?

$34.5\ g\ NH_3 \left(\frac{1\ mol\ NH_3}{17.04\ g}\right)\left(\frac{1\ mol\ Pt(NH_3)_2Cl_2}{2\ mol\ NH_3}\right)\left(\frac{300.06}{1\ mol\ Pt(NH_3)_2Cl_2}\right) = 304$

$\frac{76.4}{304} \times 100 =$ 25.1%

2. Given the following equation:

H_3PO_4 + 3 KOH ------> K_3PO_4 + 3 H_2O

   a) If 49.0 g of H_3PO_4 is reacted with excess KOH, determine the percent yield of K_3PO_4 if you isolate 49.0 g of K_3PO_4.

$49.0\ g\ H_3PO_4 \left(\frac{1\ mol\ H_3PO_4}{98.00\ g}\right)\left(\frac{1\ mol\ K_3PO_4}{1\ mol\ H_3PO_4}\right)\left(\frac{212.27\ g}{1\ mol\ K_3PO_4}\right) = 106\ g$

$\frac{49.0}{106} \times 100$ 46.2%

3. Given the following equation:

$Al_2(SO_3)_3$ + 6 NaOH ------> 3 Na_2SO_3 + 2 $Al(OH)_3$
A B

   a) If you start with 389.4 g of $Al_2(SO_3)_3$ and you isolate 212.4 g of Na_2SO_3, what is your percent yield for this reaction?

$389.4\ g\ A \left(\frac{1\ mol\ A}{294.14}\right)\left(\frac{3\ mol\ B}{1\ mol\ A}\right)\left(\frac{126.04}{1\ mol\ B}\right) = 500.6$

$\frac{212.4}{500.6} \times 100$ 42.43%

4. Given the following equation:

$Al(OH)_3$ (s) + 3 HCl (aq) -------> $AlCl_3$ (aq) + 3 H_2O (l)
A B

   a) If you start with 50.3 g of $Al(OH)_3$ and you isolate 39.5 g of $AlCl_3$, what is the percent yield?

$50.3\ g\ A \left(\frac{1\ mol\ A}{78.01\ g}\right)\left(\frac{1\ mol\ B}{1\ mol\ A}\right)\left(\frac{133.33}{1\ mol\ B}\right) =$ ~~85~~ 86.0 g

5. Given the following equation:

$\frac{39.5}{86.0} \times 100 =$ 45.9%

K_2CO_3 + 2HCl --------> H_2O + CO_2 + 2KCl

A C B

a) Balance the equation.

b) Determine the theoretical yield of KCl if you start with 34.5 g of K_2CO_3.

$34.5g\,A\left(\frac{1\,mol\,A}{138.21}\right)\left(\frac{2\,mol\,B}{1\,mol\,A}\right)\left(\frac{74.55}{1\,mol\,B}\right) = 37.2\,g\,KCl$

c) Starting with 34.5 g of K_2CO_3, and you isolate 3.4 g of H_2O, what is the percent yield?

$34.5g\,A\left(\frac{1\,mol\,A}{138.21g}\right)\left(\frac{1\,mol\,C}{1\,mol\,A}\right)\left(\frac{18.02g}{1\,mol\,C}\right) = 4.50g$

$\frac{3.4}{4.50}$ 76%

6. Given the following equation:

H_2SO_4 + $Ba(OH)_2$ ------> $BaSO_4$ + 2H_2O

A B

a) If 98.0 g of H_2SO_4 is reacted with excess $Ba(OH)_2$, determine the percent yield of $BaSO_4$ if you isolate 213.7 g of $BaSO_4$.

$98.0g\left(\frac{1\,mol\,A}{98.08g}\right)\left(\frac{1\,mol\,B}{1\,mol\,A}\right)\left(\frac{233.39}{1\,mol\,B}\right) = 233$

$\frac{213.7}{233} \times 100 =$ 91.7%

7. Given the following equation:

3 $CaCl_2$ + 2 Li_3PO_4 -------> 6 LiCl + $Ca_3(PO_4)_2$

A B

a) If you start with 82.4 g of $CaCl_2$ and you isolate 82.4 g of $Ca_3(PO_4)_2$, what is your percent yield for this reaction?

$82.4g\,CaCl_2\left(\frac{1\,mol}{110.98g}\right)\left(\frac{1\,mol\,B}{3\,mol\,A}\right)\left(\frac{310.18g}{1\,mol\,B}\right) = 76.8g\,Ca_3(PO_4)_2$

$\frac{82.4}{76.8} \times 100 =$ 107%

8. Given the following equation:

$Cr(OH)_3$ + 3HI -------> CrI_3 + 3 H_2O

A B

a) If you start with 50.3 g of $Cr(OH)_3$ and you isolate 39.5 g of CrI_3, what is the percent yield?

$50.3g\,A\left(\frac{1\,mol}{103.03g}\right)\left(\frac{1\,mol\,B}{1\,mol\,A}\right)\left(\frac{432.7}{1\,mol\,B}\right) = 211\,g$

$\frac{39.5g}{211} \times 100 =$ 18.7%